Extreme Ultraviolet Explorer

Long Look at the Next Window

"Produce ships and sails that can be used In the celestial atmosphere. Then you will also find men to man them, men not afraid of the vast emptiness of space."

Johannes Kepler

P-26

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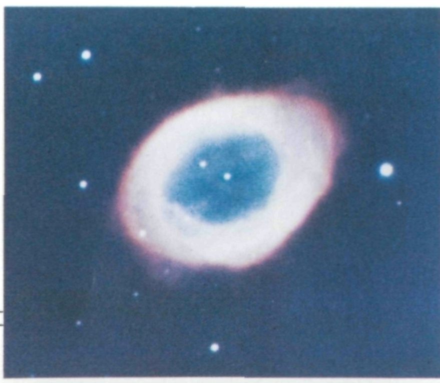
Unexplored Windows

A NASA satellite designed to scan the heavens in one of the last largely unexplored windows of the electromagnetic spectrum will be launched from Cape Canaveral, Florida in 1991. The Extreme Ultraviolet Explorer (EUVE) will be a vital element in astronomers' efforts to understand the universe by discovering what objects are present, and how they form, change, and die. Scientists want to learn what natural processes are at work in the alien environment of space, where the everyday physical conditions are often so unlike those on Earth that they cannot be duplicated usefully in the laboratory.



Extreme Ultraviolet Explorer

EUVE will map the entire sky to determine the existence, direction, brightness, and temperature of thousands of objects that are sources of so-called extreme ultraviolet (EUV) radiation. The EUV spectral region is located between the x-ray and ultraviolet regions of the electromagnetic spectrum. From the sky survey by EUVE, astronomers will determine the nature of sources of EUV light in our galaxy, and infer the distribution of interstellar gas for hundreds of light years around the solar system. It is from this gas and the accompanying dust in space that new stars and solar systems are born and to which evolving and dying stars return much of their material in an endless cosmic cycle of birth, death, and rebirth. Besides surveying the sky, astronomers will make detailed studies of selected objects with EUVE to determine their physical properties and chemical compositions. Also, they will learn about the conditions that prevail and the processes at work in stars, planets, and other sources of EUV radiation, maybe even quasars.

EUV radiation, a principal emission of many types of celestial objects, is wholly blocked by the Earth's atmosphere. Until recently, it was believed to be blocked by the interstellar gas of our Milky Way galaxy as well. As such, it was sometimes known as "the unobservable ultraviolet."

Unique Spacecraft

The EUVE will be a spacecraft of a new type. Its scientific instruments will be mounted in a single module on an orbiting platform, or spacecraft "bus," like containerized cargo that is easily transferred from an ocean freighter to a railway flatcar. The platform will provide electrical power, communications, mechanical support and pointing control for the EUVE module. Although EUVE will be launched on an expendable rocket, a new module, containing new scientific instruments, will be transported to it by the Space Shuttle once the EUVE mission is completed. The new module will be

Three examples of interstellar gas and dust.
LEFT: The North American Nebula in Cygnus
TOP: Ring Nebula in Lyra
ABOVE: Orion's Horsehead Nebula

RIGHT: Artist conception of the EUVE spacecraft in orbit

swapped for the EUVE unit by the crew, using the Shuttle's Remote Manipulator System. This design allows reuse of unmanned spacecraft just as the Shuttle allows reuse of a manned vehicle. This concept also allows for ready servicing in space, should spacecraft subsystems or instruments degrade.

To develop the EUVE, NASA enlisted the University of California at Berkeley and the NASA/Goddard Space Flight Center in Greenbelt, Maryland. The Berkeley astronomers and physicists, led by Professor Stuart Bowyer, have pioneered the exploration of space in the extreme ultraviolet with investigations by sounding rockets and manned spacecraft. Also Berkeley has developed the necessary technology and instruments for EUV astronomy, and pioneered the scientific interpretation of the results of such experiments. Goddard has a proud history as the developer of unmanned Explorer-class and observatory-class satellites, a world-wide tracking/communications network, and associated ground control centers. Goddard also pioneered the development and operation of the first reusable unmanned spacecraft designed specifically for recovery and servicing in space.

Advanced Technology

EUVE will carry a full complement of telescopes, detectors, and a spectrometer. The equipment incorporates advanced technology from the United States and Japan. The EUVE instrumentation will be mounted in a Payload Module on NASA's new reusable Explorer Platform, designed and managed by the Goddard Space Flight Center (GSFC) and built by the Fairchild Space Company. The Payload Module was designed, built and tested at GSFC.

Cosmic Survey

The scientific mission of EUVE will consist of a six-month all-sky survey, in which the heavens are mapped in four channels of the extreme ultraviolet spectrum while a narrow band in the sky is mapped at even greater sensitivity in a deep-sky survey. This will be followed by a spectroscopy phase of at least one year.

In the spectroscopy phase, individual targets, whether discovered in the all-sky and deep-sky surveys or identified from other information, will be analyzed in detail through individual observations made with an on-board EUV spectrometer. Typically, a spectrometer observation will last from one to several days. The EUVE surveys will be conducted by the Berkeley astronomers, while the spectroscopic studies will be performed by Guest Observers who may be associated with scientific or educational institutions. NASA Headquarters, in Washington, D.C., will select these Guest Observers from throughout the United States and around the world, on the basis of scientific merit.

When the extreme ultraviolet astronomy research is complete, a Space Shuttle will dock with the EUVE so that the Shuttle crew can bring it onboard with the Remote Manipulator System (robot arm). The extreme ultraviolet astronomy payload will be replaced with the payload for a new scientific investigation, the X-ray Timing Explorer (XTE).

Astronomical Windows

The EUVE studies come as a logical complement to past Explorers that have scanned space in the infrared, ultraviolet, x-ray, and gamma-ray regions. As each of these so-called "windows" of the universe has been opened to detailed study by Explorer-class instruments, wholly unexpected objects and phenomena have been discovered, and unusual physical

Milky Way Galaxy as a satellite streaks in front of it

processes have been found to be at work. Astronomers learned that they can no more study our galaxy—or a single star—in proper depth with one kind of telescope operating in a single spectral region, than biomedical researchers can study the human body

Final inflation stage of balloon carrying scientific instruments at sunrise near Palestine, Texas.

with a single kind of microscope, chemical tool, or analytical procedure. Just as each kind of biochemical technique involves different types of laboratory apparatus or a different set of chemical reagents, each form of electromagnetic radiation or light requires distinct types of telescopes, associated instruments, and sensors for its study.

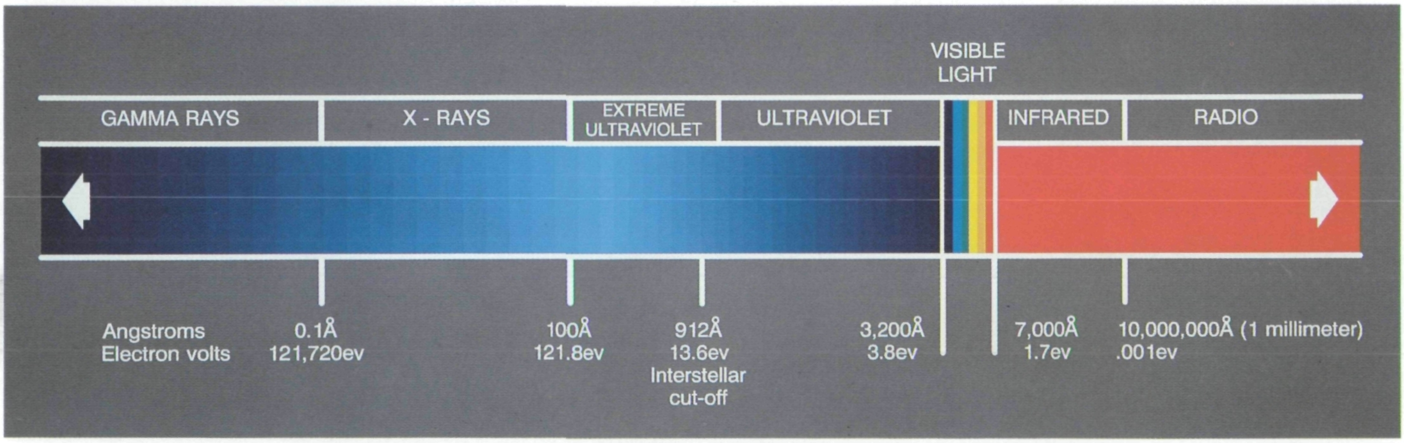
New Secrets

Each new window brings unexpected marvels into the astronomers' view. Mapping the sky in infrared light, the Infrared Astronomical Satellite, a joint United States-United Kingdom—Netherlands spacecraft, discovered what may be planetary systems in formation, circling stars beyond the Sun, and the eerie glow of dust trails of long-vanished comets that once orbited in our solar system.

Einstein, as the High Energy Astrophysics Observatory-3 satellite was popularly known, found and investigated binary stars in the Milky Way and a neighbor galaxy in which one member is almost surely a black hole. A black hole is a condensed dead star whose gravity is so powerful that even light cannot escape it.

The International Ultraviolet Explorer (IUE), operated jointly by NASA, the European Space Agency and the United Kingdom Science and Engineering Research Council, found a hot corona surrounding our Milky Way galaxy. IUE also discovered a glowing shell of gas caused by the collision of high- and low-speed winds emitted by a star that later exploded as a supernova, and a previously undetected form of sulfur in a comet that made a close swing past the Earth.

Telescopes sensitive to gamma rays aboard balloons, rockets, and the Solar Maximum Mission satellite detected a spectral emission from the central region of the Milky Way that is caused by the mutual annihilation of matter and antimatter. The message is clear: open a new window on space and we are sure to find as-yet-unknown secrets of the universe.



Artist's conception of the electromagnetic spectrum

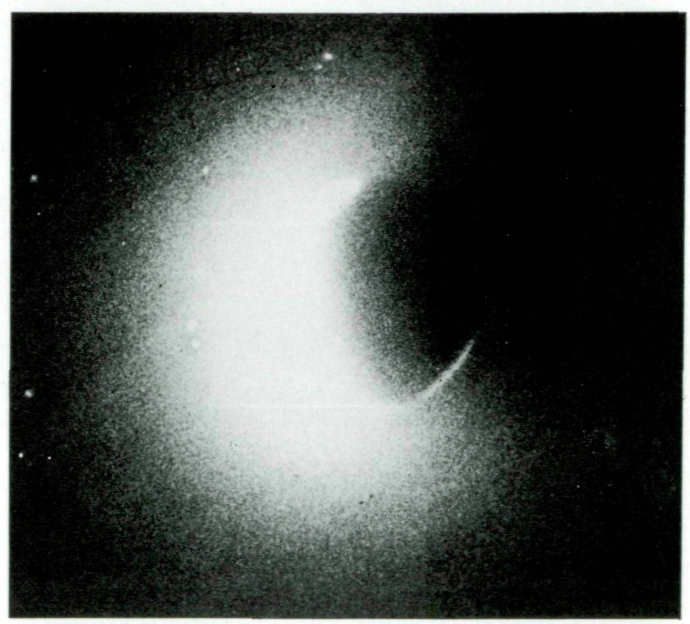
Extreme Ultraviolet Radiation

EUV radiation is defined as the range of the electromagnetic spectrum that lies at shorter wavelengths (higher energies) than ordinary ultraviolet light and at longer wavelengths (lower energies) than x-rays. As such, it consists of light with wavelengths between about 100 Angstroms and 1000 Angstroms. (One Angstrom, a unit of length named for the Swedish physicist Anders Angstrom, equals one one-hundred-millionth of a centimeter, or about four billionths of an inch.)

Both ordinary ultraviolet light and x-rays also are blocked by the atmosphere. They are known to reach the Earth's vicinity from very great distances in space, and have been extensively studied by satellite observatories above the atmosphere, developed by the United States and other technologically-advanced nations. For example, ultraviolet radiation from stars, nebulae and galaxies was studied by NASA's Orbiting Astronomical Observatories and by the Astronomy Netherlands Satellite, and is under investigation by the International Ultraviolet Explorer.

X-rays from stars and galaxies have been explored by the High Energy Astrophysics Observatories, the Small Astronomy Satellite "Uhuru," and by such foreign craft as ESA's EXOSAT, Japan's TENMA and GINGA, Germany's ROSAT and the Soviet Union's MIR Space Station. Yet, despite almost two decades of work, exploration of space in the extreme ultraviolet has been minimal.

Sagittarius star cloud in the direction of the center of the Milky Way



Naval Research Laboratory experiment aboard Apollo 16 provided this image of our geocorona

Roadblocks to Extreme Ultraviolet Astronomy

The study of the universe in the extreme ultraviolet, still in its infancy despite space experiments flown since 1971, has been hampered by three factors that astronomers can now surmount with the EUVE: accepted "knowledge," geocoronal interference, and technological limitations.

Accepted Knowledge

Conventional wisdom on our Milky Way galaxy was painstakingly developed through extensive observations with radio and optical telescopes on the ground during the 1950s. These observations suggested that the disk of our spiral-shaped galaxy is pervaded by an interstellar medium of hydrogen, helium, and less abundant gases. Both hydrogen and helium absorb extreme ultraviolet light. Calculations indicated that the hydrogen alone was enough to cut off the extreme ultraviolet light from almost any known object beyond our own solar system, which is located in the galactic disk. As early as 1959, experts asserted that it would be impossible to observe objects much beyond the limits of the solar system in the extreme ultraviolet. It was not until 1975 that a crucial experiment in space, carried out by Professor Bowyer and his associates on the Apollo-Soyuz mission, disproved this view.

Technological Limitations

Extreme ultraviolet light cannot be collected and focused usefully with telescopes of conventional design; if ordinary optical telescopes were used, most of the individual photons of extreme ultraviolet light would be absorbed in the coated surfaces of the mirrors or scattered in directions away from the optical axis.

The extreme ultraviolet can be observed usefully only with telescope mirrors designed for operation in grazing incidence mode, in which the incoming light strikes a mirror at a very small angle to its surface like a stone skipping off the sea. Thus, in an extreme ultraviolet telescope, the primary or light-collecting mirror does not face directly toward the target like the mirror in a conventional telescope or a searchlight.

Instead, while the EUV telescope points at the target like a gun, its primary mirror is positioned roughly like the inner surface of the gun barrel, or like the inner surface of a cone opening toward the incoming light.

Even if appropriate grazing incidence telescope mirrors are used, problems remain. When the extreme ultraviolet light strikes the carefully shaped telescope mirrors at angles of a few degrees to their surfaces, the slightest local irregularity interferes with the skipping light rays, scattering them in wrong directions like golf balls that hit slight irregularities on the green and veer away from the cup. Accordingly, the mirror surfaces must be made with exceptional smoothness, even by the demanding standards of the optician.

There are other technological limitation as well. When EUV astronomy began in the 1960s, the available detectors—the devices that actually sense the EUV radiation collected by a telescope—were relatively insensitive. Also, there were no diffraction gratings—optical components that spread light into a spectrum—that were well-suited to use in the EUV. The EUV represented such a new departure for astronomers' studies that there was no national standard for calibrating laboratory measurements of the intensity of EUV light.

Geocoronal Interference

At the outer limits of the Earth's atmosphere, far above almost all orbiting satellites, the ambient gases are so thin that a gas atom can orbit all the way around the Earth without striking another atom. Under such conditions, the gases in this region readily escape the Earth's gravity. They make up the geocoronoa, a huge region that thins out into interplanetary space.

In the geocorona there are also helium ions, atoms of helium that have each lost one electron. These ions are prevented from escaping into space by the Earth's magnetic field. The helium ions scatter, that is, reflect in all directions, EUV light emitted by similar helium ions in the Sun.

As a result, if space travelers on the Moon or Mars were to look down on the Earth with eyes somehow sensitive to extreme ultraviolet radiation, they would see a huge luminous zone around our planet, consisting of the geocoronal helium ions glowing in the extreme ultraviolet light of the Sun.

Other constituents of the geocorona also scatter solar radiation. Located above the Earth, but below or within the geocorona, satellite telescopes are severely hampered by this geocoronal glow when they operate in the extreme ultraviolet. At some wavelengths, the glow may be thousands of times brighter than a celestial target of interest when viewed with a given extreme ultraviolet telescope. There appear to be only two ways to minimize this interference: locate the telescope outside the geocorona or operate it in a highly selective manner.

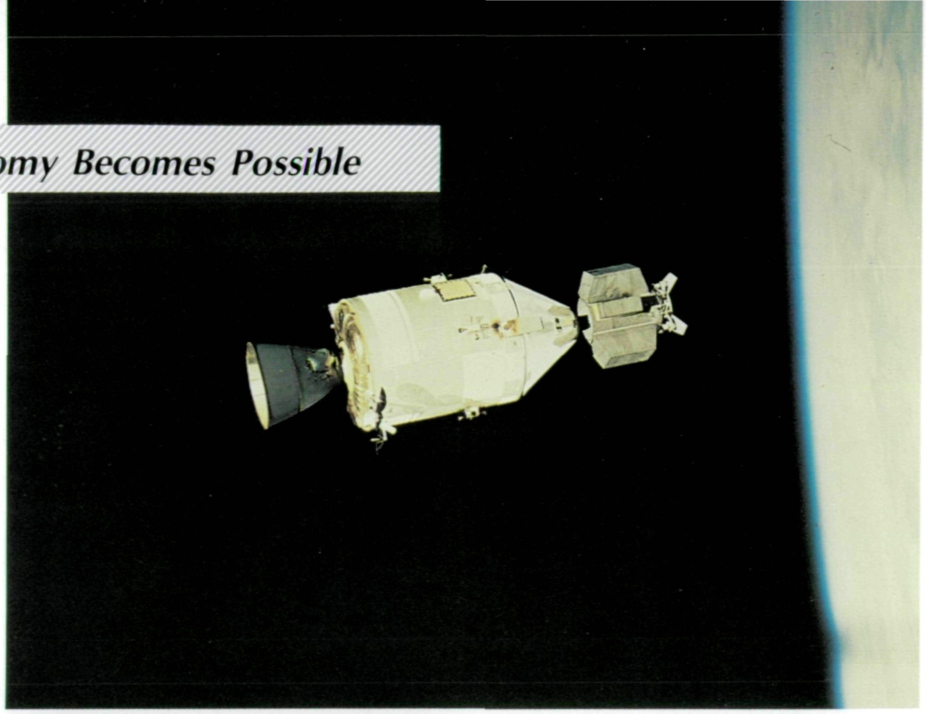
Positioning a spacecraft such as EUVE outside the geocorona would make it impossible to service it with the Space Shuttle in the event of malfunction, and impossible to revisit it with the Shuttle to replace the payload at the end of its intended operating life. Therefore, EUVE will be operated in low-Earth orbit, below the geocorona, but generally will make observations at night, when the geocorona causes the least interference.

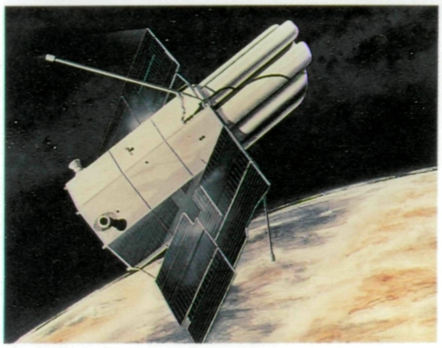
A remaining source of natural interference, called the very local interstellar medium, hampers EUV observations and cannot be overcome with current technology. The very local interstellar medium consists of electrically neutral atoms of interstellar gas that sweep through the solar system as the Sun and the planets move through the Milky Way. Helium atoms in this medium scatter EUV radiation from helium in the Sun, producing a dim, interfering glow that EUV astronomers cannot avoid.

Extreme Ultraviolet Astronomy Becomes Possible

Recent advances in space astronomy and in technology make it possible for the EUVE mission to explore space in a wavelength window previously called the "unobservable ultraviolet." The interstellar gas of the Milky Way was once thought to be a smoothly distributed, absorbing fog that thoroughly blocks extreme ultraviolet light. On further inspection, it was revealed to be a complex array of dense clouds embedded in a thinner and hotter gas, honeycombed by very thin regions shaped like bubbles and tunnels, like an ant's nest or a rabbit warren beneath the seemingly solid ground.

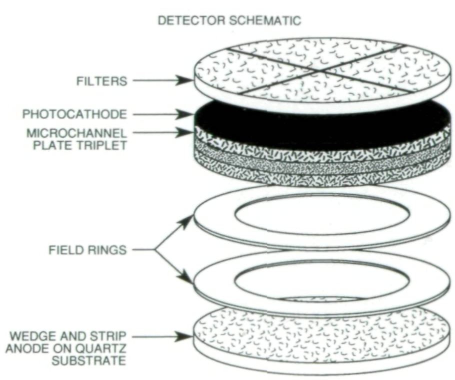
Detectors, diffraction gratings, mirrors, filters, and calibration methods have been developed and optimized for use in the EUVE. Detectors, the crucial components that sense the radiation collected by the telescopes, provide a good example. With a telescope of a given size, a more sensitive detector allows the astronomer to discover and measure fainter sources. At first, the detectors available for sensing EUV radiation were not very sensitive.





ABOVE: American Apollo spacecraft photographed by Soviet cosmonauts in joint US/USSR Apollo-Soyuz program

LEFT: Artist's conception of the Copernicus astronomical observatory

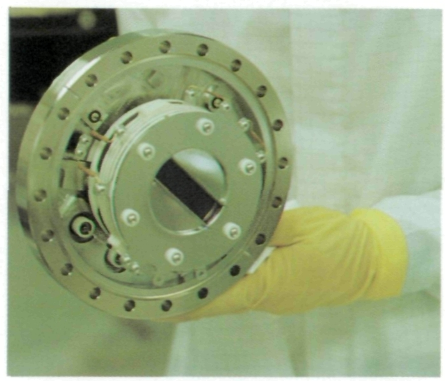


The Berkeley scientists developed so-called photon counting detectors for the EUV, work recognized by the award of patents and the publication of many technical papers. At first, the detectors were simple photometers that registered only the intensity of EUV radiation, but now high-resolution imaging detectors can sense the position of each incoming photon of EUV light within the field of view. They can record also the exact moment at which the photon was received. Like the improvements in the other technology areas, the improved EUV detectors may prove beneficial in applications outside astronomy.

Thin Bubble

Experimental EUV telescopes flown on manned spacecraft, unmanned sounding rockets, and interplanetary probes have detected about a dozen EUV-emitting stars in the Milk Way. They have revealed also that there are lines of sight along which we can see to distances of many light years from the Earth (one light year equals about 5.9 trillion miles, or 9.5 trillion kilometers).

Further, from studies by NASA's Copernicus satellite (Orbiting Astronomical Observatory–3) and the IUE, it appears that our solar system, including the Earth, is located in one of the thin bubbles of interstellar gas, an ideal location from which to explore to significant distances in the extreme ultraviolet. As a result of these findings it appears that the EUVE, rather than being blocked from observing beyond the solar system by the interstellar gas, will be able to survey objects in our galaxy out to a distance of about 300



LEFT: Schematic of EUVE detector

RIGHT: One of the EUVE flight detectors

light years in many directions. EUVE will view to even greater distances in a limited number of directions, perhaps including a few lines of sight extending wholly out of our galaxy.

Apollo-Soyuz

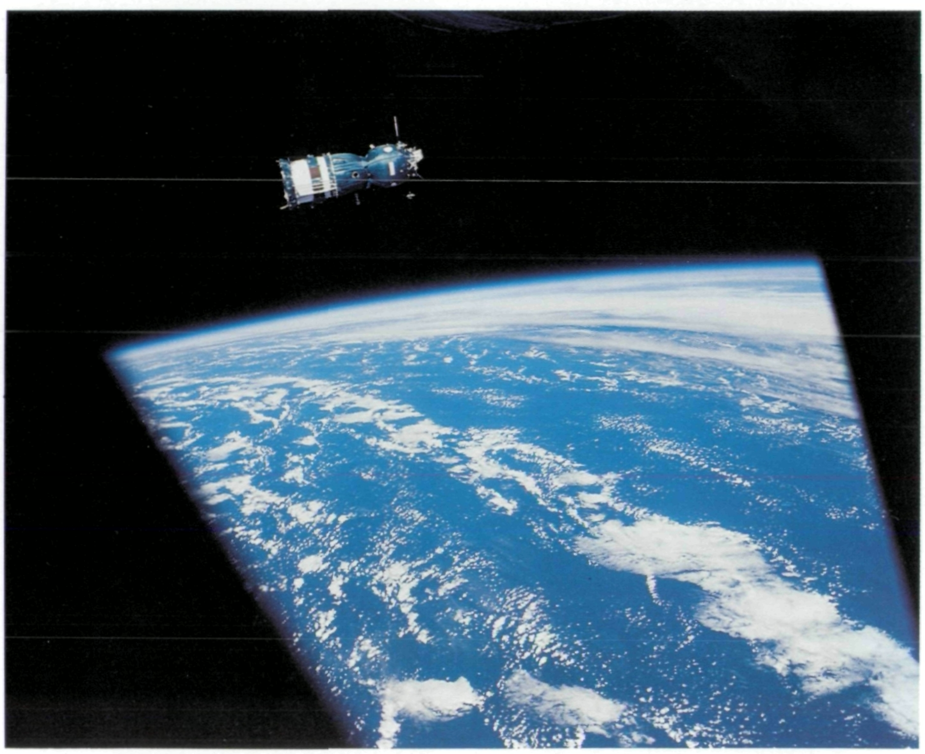
Evidence that EUV astronomy is feasible came during the 1975 Apollo-Soyuz Test Project, a manned mission with on-orbit rendezvous and docking of space capsules from the United States and the Soviet Union (the Apollo-Soyuz work followed a series of inconclusive EUV astronomy experiments by sounding rockets).

After the joint activities of the astronauts and cosmonauts were concluded and the Soviet Soyuz-19 capsule separated from Apollo, the NASA crew repeatedly oriented their command and service module to point a 14-½-inch EUV telescope designed at Berkeley at 30 preselected celestial targets. Five of the targets were detected, including one, the unusual hot star HZ 43 in the constellation Coma Berenices. HZ 43 was such a strong source of extreme ultraviolet light that it was recognized when raw data telemetered from Apollo were traced on a chart recorder at the NASA Johnson Space Center in Houston, Texas.

White Dwarfs

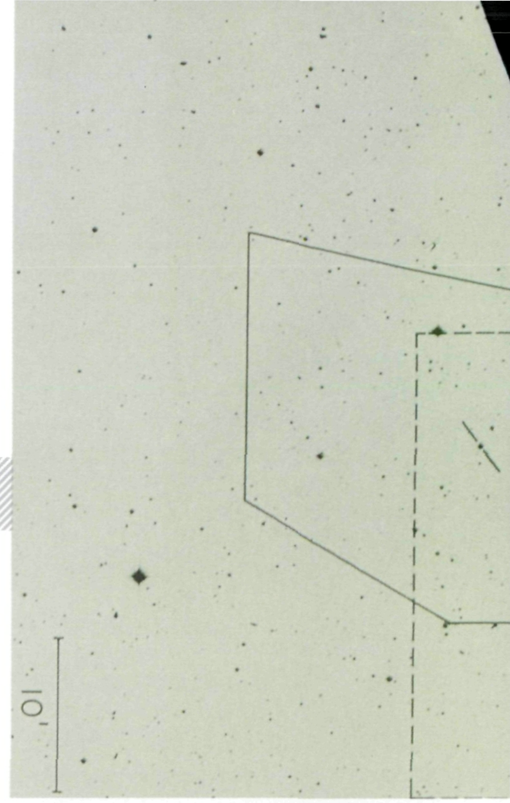
The 1975 discovery of intense extreme ultraviolet radiation from HZ 43 was a triple milestone in astrophysics. It established the feasibility of exploring the galaxy through the extreme ultraviolet window. It identified HZ 43 as the hottest and most luminous white dwarf star then known. It proved also that white dwarf stars, although dim as seen in ordinary visible light, may be beacons in the heavens when viewed through the extreme ultraviolet.

White dwarf stars are the final evolutionary stage of stars such as our Sun. They burn hydrogen by nuclear reaction for billions of year, then blow up into helium-burning red giants, throw off their outer layers and eventually become hot, dense objects—the white dwarfs—that cool and fade thereafter throughout eternity.



From a rendezvous window, an American astronaut snapped this photo of the Soviet Soyuz spacecraft

Unusually hot star HZ 43 detected by telescope aboard Apollo/Soyuz spacecraft



Exploring Space: Rockets, Explorers, and Observatories

Through three decades of the space age, astronomers and space engineers have developed a proven method for the exploration of space through new windows in the electromagnetic spectrum. There are so many unknowns when a particular spectral window on the universe is yet to be explored, that it is difficult and even inappropriate to plan a major space facility for that purpose.

Instead, simple experiments are first conducted in which relatively crude and inexpensive measurements are made from low-cost platforms to learn "What's out there?" and see what kind of equipment functions well in space.

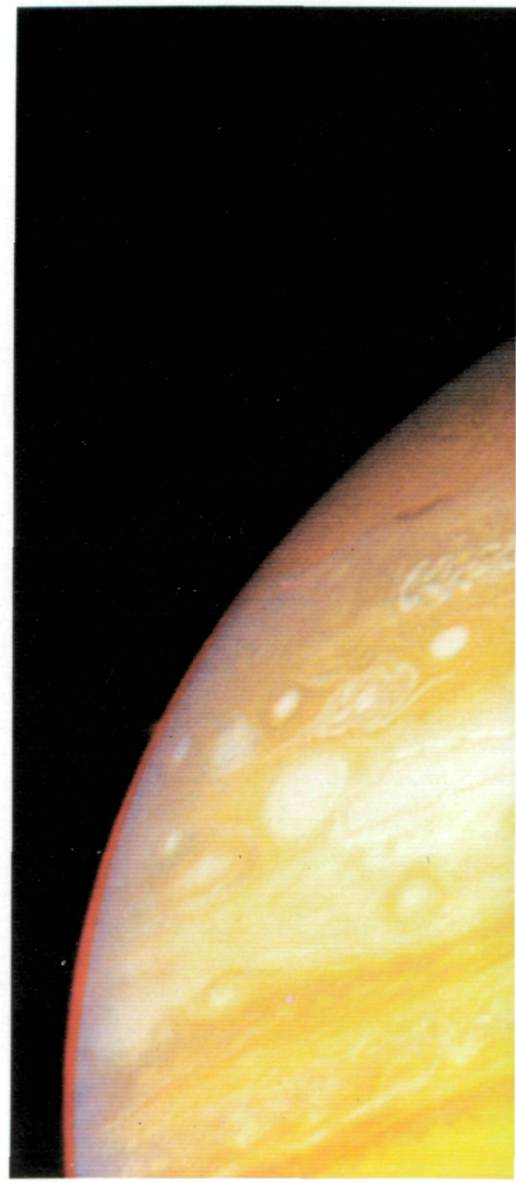
Scorpius X-1

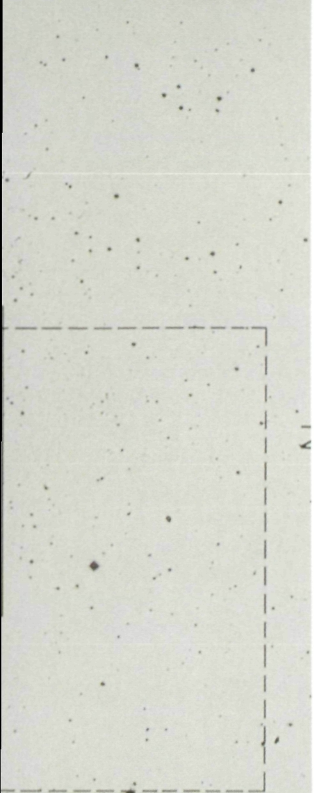
Thus, the pioneering observations in x-ray astronomy were made from sounding rockets, with results that included the discovery of the first known x-ray source beyond the solar system, the strange binary star, Scorpius X-1. The results of these suborbital studies in x-ray astronomy showed scientists how to design appropriate instruments for simple exploratory satellites.

Uhuru

Explorer 42, better known as Small Astronomy Satellite-1, or Uhuru, was able to catalog hundreds of x-ray sources around the sky, and to record important physical data on Scorpius X-1 and many of the others. From this and even more sensitive observations by the later Einstein satellite, astronomers learned that the sky is full of intense sources of x-ray emission that blink on and off, occasionally flare to great intensity, and constantly change like the flashing colored lights on a Christmas tree.

The ultimate stage in exploring a spectral window is to follow the surveys made by Explorer satellites, once the data have been carefully studied, with a powerful, highly instrumented spacecraft. The future Advanced X-ray Astrophysics Facility (AXAF) of the "Great Observatory" Class is one example.





Opening the Extreme Ultraviolet

The initial explorations in EUV astronomy were conducted by sounding rocket experiments and by the experiment on the Apollo-Soyuz Test Project. Astronomers at other United States institutions and in Europe also contributed to EUV astronomy.

Additionally, the Voyager 1 and 2 interplanetary space probes, which were sent to Jupiter and beyond, carried spectrometers. Developed by the University of Southern California, these probes are still obtaining valuable spectra in a portion of the EUV range for selected bright targets.

EUVE is likely to detect and study classes of EUV targets such as white dwarf stars and flare stars, early type-B stars with shock-wave-heated winds, exploding stars called dwarf novae, and others. These studies laid the foundation for conducting an all-sky survey in four EUV wavelength channels with EUVE, for making a complementary survey in a portion of the EUV with the German-U.K.-U.S. cooperative mission, ROSAT, and for the deep survey of a limited sky region by EUVE, along with EUV spectroscopy on selected EUVE targets.

Once the observations of the EUVE are completed and analyzed, investigators will determine whether the phenomena detected justify further study with an even more advanced observatory.

Voyager-1 photo of Jupiter and two of its satellites, Io (left) and Europa, above Jupiter's Great Red Spot

The EUVE Mission

EUVE is scheduled for launch in Fall 1991 aboard a McDonnell Douglas Delta II rocket from Launch Complex 17 at Cape Canaveral, Florida. The Delta II will place EUVE in a 550-km (340-mile)-altitude circular orbit, inclined at 28 degrees to the Equator.

After the Delta II rises above the lower layers of the atmosphere, its 10-foot-diameter protective fairing will be jettisoned in preparation for separating the spacecraft from the launch vehicle. The fairing protects EUVE from extreme heat and other adverse environmental factors that develop during powered flight through the lower atmosphere. Although lofted by an expendable launch vehicle, the spacecraft is designed for on-orbit recovery, servicing, and payload replacement by the Space Shuttle.

Orbital Checkout

Following launch, there will be a period of on-orbit checkout lasting about 30 days. Ground controllers will verify safe turn-on and operation of the EUVE spacecraft subsystems. During this time, most of the molecules of vapor trapped in the spacecraft materials will emerge and escape into space, a familiar process known as outgassing. Until outgassing is complete, the EUVE telescopes will remain shut to avoid contamination of their ultraclean optical surfaces. Then the telescopes will open and Berkeley scientists will verify their proper operation.

All-Sky Survey

The next six months of the orbital life of EUVE will be devoted to the principal scientific program of the Berkeley astrophysicists. EUVE will scan the sky simultaneously with three telescopes equipped with a variety of carefully designed filters. Over the six-month period, the entire sky will be mapped and the locations and brightness of thousands of objects will be measured in four wavelength channels of the EUV. To reduce interference with the sensitive survey by the geocoronal glow of hydrogen and helium, most observations will be made only during the night portion of the orbit. (In a low-Earth orbit such as that of EUVE, the Sun rises and sets 16 times per day).

Deep Survey

Simultaneously with the all-sky survey, a deep survey telescope will take longer duration measurements along a band in the sky centered on the ecliptic, the projected location of the Earth's orbit in the sky. This telescope, also operating only during orbit night, will view along the shadow cone of the Earth, which extends far out into interplanetary space. This operational procedure will minimize interference by geocoronal light to the greatest extent possible with a satellite observatory located below the geocorona.

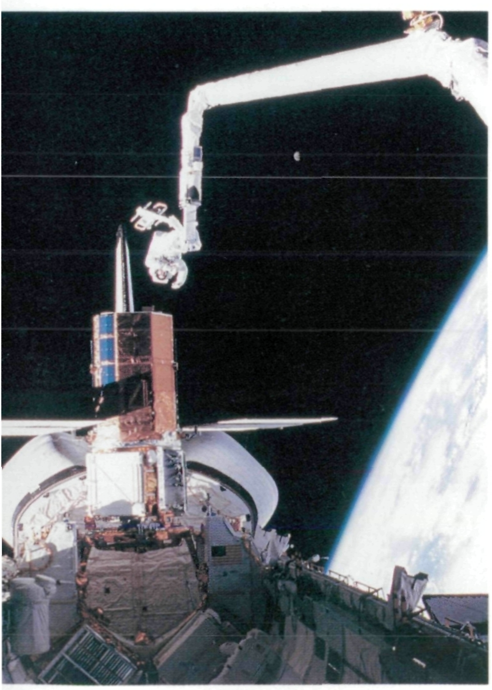
By its combination of longer exposure times and less geocoronal interference, the deep survey will explore a limited band of the sky with a sensitivity that is from 10 to 50 times greater than the sensitivity of the all-sky survey.

LEFT: The Delta II commercial space booster, launch vehicle for EUVE

Survey Phase

The EUVE spacecraft will rotate around its spin axis. The three survey telescopes or "scanners" will point out in the equatorial plane of the EUVE, so that each telescope scans a strip five degrees wide along a great circle in the sky. (Such a strip is about 10 times as wide as the full Moon.)

One end of the rotation axis of the EUVE will be kept pointed at the Sun. As the Earth moves halfway around its orbit of the Sun during six months, and EUVE continues to revolve around the Earth, each great circle traced by an EUVE scanner will slowly sweep all the way around the sky, and each of the three scanners will separately map the whole sky. At the same time, the deep survey telescope will always point along the rotation axis in the direction opposite the Sun. Accordingly, it always will point down the Earth's shadow cone and will trace out half of a great circle on the sky during the six-month interval of the all-sky survey.



LEFT: Trifid Nebula in Sagittarius

ABOVE: Astronaut at end of Space Shuttle's remote manipulator arm approaching Solar Maximum Mission spacecraft to make repairs

Spectroscopy Phase

From the many interesting objects that will have been discovered during the EUVE all-sky survey and other objects already known from other astronomical investigations, Guest Observers will choose targets for detailed analysis. Using the EUV spectrometer that incorporates advanced diffraction gratings, the Guest Observers will study these targets.

Better Than Voyager

Because EUV radiation arriving from the stars is generally so weak that individual photons of extreme ultraviolet light must be separately detected and counted, the exposure times for these spectroscopic studies are likely to range from one day to several days per observation. The result will be detailed spectra, which will extend over the full range of extreme ultraviolet wavelengths, with 10 times the spectral resolution of the EUV spectrometers on the Voyager probes. (The Voyager instrumentation was much less sensitive in the EUV than the spectrometer and it was possible to observe only a limited number of previously known objects; no survey was conducted.)

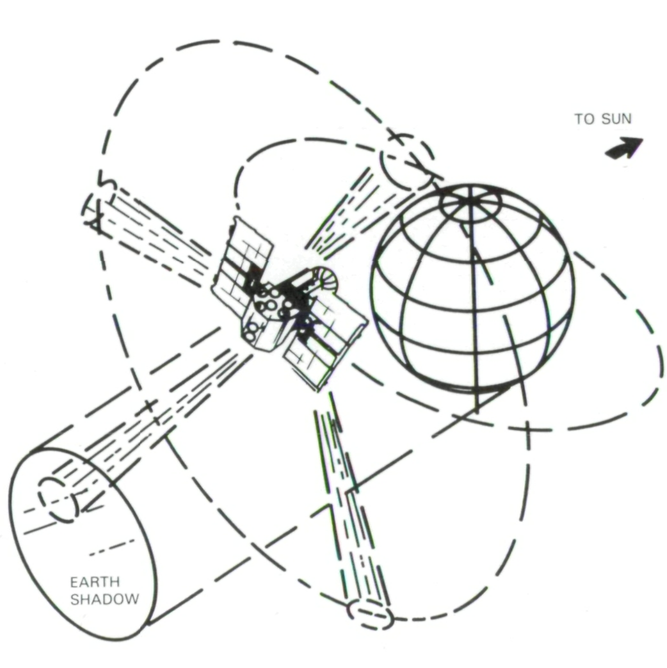
As the deep survey telescope collects light simultaneously for the spectrometer and for its deep survey detectors, the fields of view around the spectroscopy targets will be surveyed too. The Spectroscopy Phase is expected to last at least one year.

Retrieval

After the EUVE mission is completed, the Space Shuttle will rendezvous with EUVE so the spacecraft can be brought onboard the Shuttle by a Mission Specialist operating the Remote Manipulator System, a 15-meter (49-foot) mechanical arm equipped with grapples. The EUVE Payload Module will be removed from the Explorer Platform on which it is mounted, and an X-ray Timing Explorer (XTE) Payload Module will be installed in its place. If necessary, platform subsystems can be replaced.

The Explorer spacecraft, now operating as the X-ray Timing Explorer, will be released in orbit. The XTE will investigate rapidly varying phenomena in cosmic x-ray sources, such as outbursts and oscillations in x-ray emissions. The intended operating lifetime of the Explorer Platform, starting with the EUVE launch, is 10 years, so that other experiments can be mounted later.

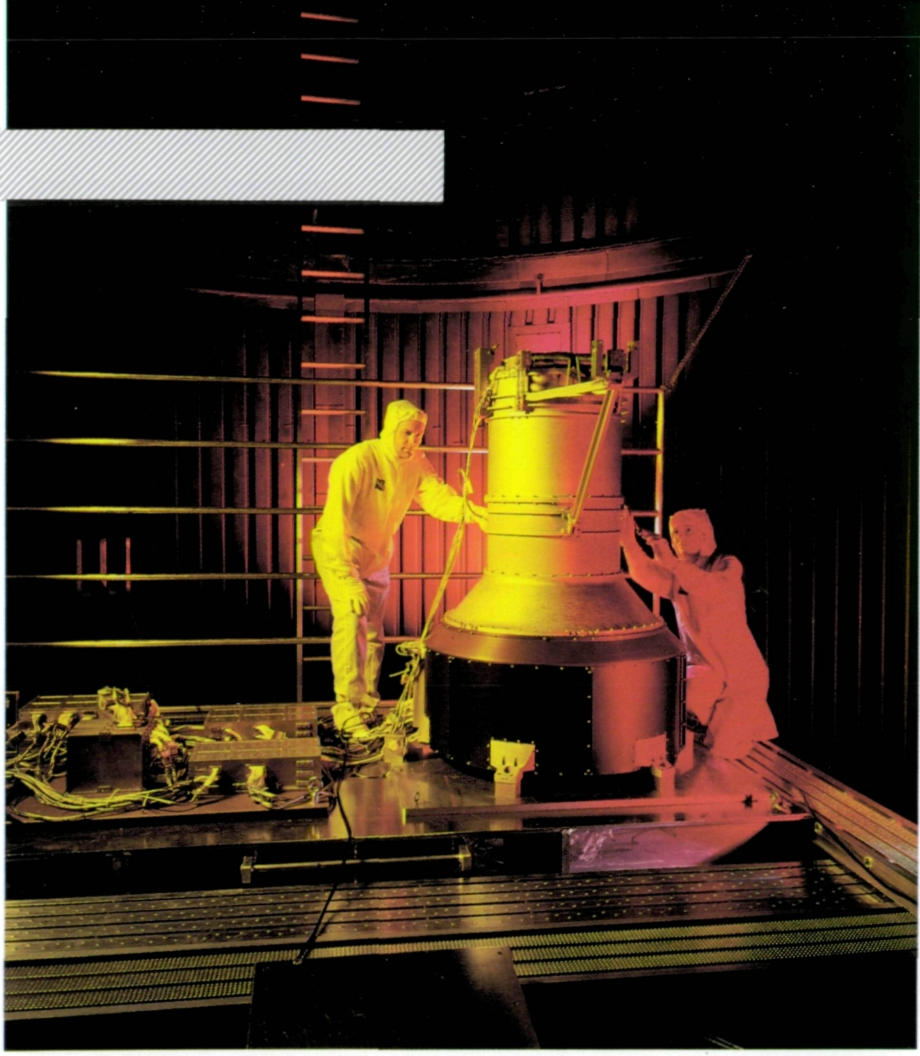
BELOW: Schematic showing EUVE in relationship to Earth's shadow and our Sun



The EUVE Instruments

The three scanner telescopes, and the deep survey telescope/spectrometer of the Berkeley-developed EUVE payload represent the state-of-the-art in extreme ultraviolet astronomy. The instruments and their associated electronics packages are mounted in the Payload Module, which is installed as a unit on the Explorer Platform. Each telescope uses metal mirrors that reflect EUV light at grazing angles, like the rising Sun seen mirrored in the sea. The telescopes are equipped with filters made from thin films of metals and other substances, layered to isolate desired regions of the EUV spectrum for observation. The reflecting telescope concepts are derived from those proposed in the 1950s by the German physicist, Hans Wolter, who attempted to design an x-ray microscope.

Each of the three EUVE scanner telescopes is about as large as a 55-gallon oil drum and weighs about 188 kilograms (about 260 pounds). The deep survey telescope/spectrometer weighs about 323 kilograms (about 710 pounds).



ABOVE: Technicians working on spectrometer in large thermal vacuum chamber

Smooth Mirrors

Different mirror designs are used for scanner telescopes that observe the longer and shorter wavelength EUV light. This is necessary to efficiently collect the light while discriminating where necessary against x-rays that would otherwise contaminate the measurements made through some of the filters. For the same reason, some of the mirrors are gold-coated to increase EUV reflectivity, while others are left without such coatings in order to attenuate x-rays that strike their amorphous (non-crystalline) nickel surfaces. The metal mirrors were turned on a computer-controlled diamond lathe at the Lawrence Livermore National Laboratory. The mirrors are polished to far greater smoothness than normally attained by skilled opticians in order to insure low scattering of EUV light, especially at the shortest wavelengths. Specifically, the surface roughness has been reduced to less than 15 Angstroms, or about 60 billionths of an inch. The mirrors will focus EUV light from a star or other point source to an image of about 10 arcseconds, making a star seem like a spot that is about 180 times smaller in diameter than the full Moon. Although this is larger than the image of a star formed by a conventinal optical telescope operating in visible light, it sets a new standard for EUV telescopes.

Spectrometer

The EUVE spectrometer represents a novel design, providing maximum energy throughput and spectral resolution in the extreme ultraviolet. The more throughput the spectrometer has, the fainter the sources it can detect in a given exposure time with a given telescope. As the spectral resolution of a spectrometer is increased, it becomes possible to separate independent spectral lines, arising in atoms and ions of different types, which are blended together when observed at lower resolution and are thus difficult or impossible to study.

Sir Isaac Newton

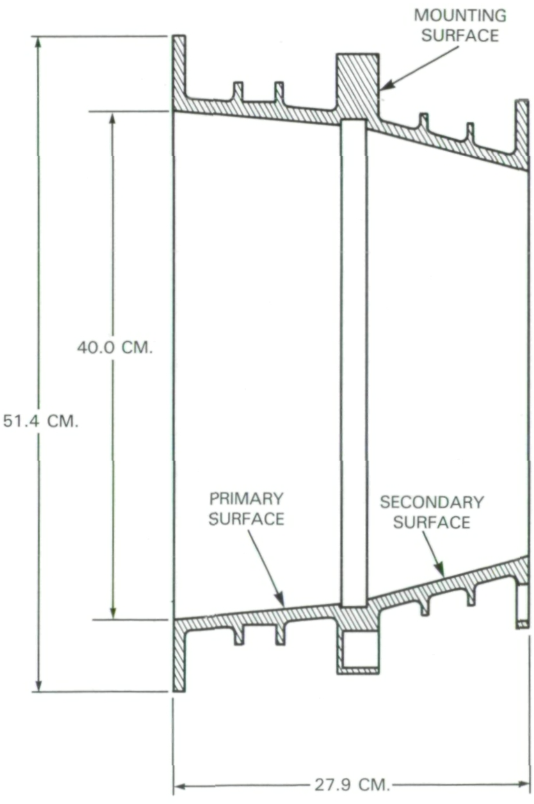
The key component of a spectrometer is the dispersing element, meaning the optical device that spreads light out into a spectrum. The most familiar dispersing element is the glass prism made famous by Sir Isaac Newton, who observed sunlight that passed through his prism to be spread out into the colors of the rainbow. Modern spectrometers usually are provided with dispersing elements called diffraction gratings. A diffraction grating is a plate of glass or similar material that is provided with a thin, smooth metal coating in which thousands of very narrow, parallel grooves are ruled at precisely controlled spacings. When light waves reflect from the grooves, they bend slightly at the edges of the grooves (a phenomenon called diffraction) and thus change direction. The amount of bending depends on the color or wavelength. Therefore, the different wavelengths are bent by different amounts and the incoming light, upon reflecting from the grating, is diffracted into a spectrum.

Cutting Edge

The key feature of the EUVE spectrometer is the use of three diffraction gratings of a new type in a converging light beam and the existence of only three reflecting surfaces in each of the three wavelength channels. By using the new kind of diffraction gratings, in which the spacing between grooves or "lines" is continuously varied from one end of a grating to the other, and by placing the gratings in the converging beam of the telescope rather than in a parallel light beam, the Berkeley designers have achieved high spectral resolution with only three reflections per channel. Each reflection of a light beam, especially an EUV light beam, results in some loss of light. Therefore, by minimizing the number of reflections, the energy throughput is maximized.

LEFT: Technician in clean room environment inspecting scanning telescope

BELOW: Schematic showing EUVE mirror design



The Explorer Platform

The EUVE spacecraft consists of a Payload Module that contains the EUVE scientific instruments and associated electronics packages. Also, it includes an Explorer Platform that provides structural support, two-way communications with the ground, electrical power, stabilization, and pointing control. This spacecraft design, developed at the Goddard Space Flight Center (GSFC), represents a natural evolution of the earlier Multi-Mission Modular Spacecraft design, as first used by GSFC in the Solar Maximum Mission spacecraft.

The Solar Maximum Mission (SMM) spacecraft, launched in 1980, was retrieved by the Space Shuttle Challenger, repaired onboard, and released back into orbit during a single, manned flight in 1984. The Solar Maximum Repair Mission demonstrated for the first time that a spacecraft designed for on-orbit replacement of individual subsystems could be repaired safely in space. The Explorer Platform developed for EUVE and subsequent missions carries this design philosophy further by providing a generally adaptable Platform Equipment Deck, which can accept science payloads of many kinds, including some that may not have been envisioned when the platform was actually built. The key to this new design is the concept of the Payload Module, which may contain any scientific instruments that fit within the limits of available space and power. Rather than mounting individual scientific instruments to the spacecraft, as was done in the Solar Maximum Mission, the entire complement of EUVE instruments, contained in a single, replaceable Payload Module, are mounted to the Platform Equipment Deck of the Explorer Platform as a single unit. By the same token, the Payload Module can be removed at a future date—a process that will be performed in space—and replaced by a new module that mounts on the deck in the same way, but which contains a wholly different set of scientific instruments.

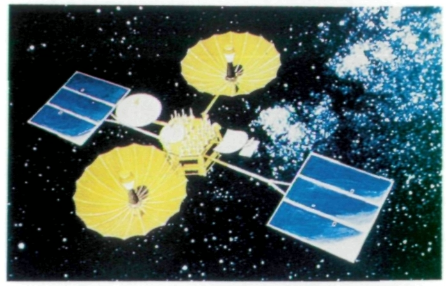
Solar Arrays

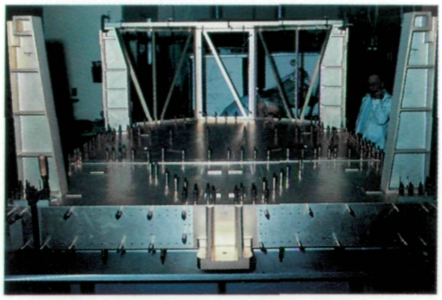
All power on the EUVE spacecraft comes from the Sun. Solar energy is converted to electricity in photovoltaic cells contained in the spacecraft's solar arrays and is stored in batteries.

The Solar Maximum Mission (SMM) was designed so that the instruments and therefore a fixed surface of the spacecraft, would always point at the Sun. On the other hand, EUVE will point telescopes in directions away from the Sun, and future payloads on the same Explorer Platform may need to point in still other directions. Accordingly, while the solar panels on SMM were fixed in orientation with respect to the spacecraft structure, the solar panels on the Explorer Platform must be capable of articulation, that is, for pointing at the Sun as the spacecraft points instruments in first one direction and then another. Also, the EUVE arrays are larger, incorporate more efficient photovoltaic cells, and produce more power than the SMM solar arrays.

Toaster Oven

At the beginning of the EUVE mission, the solar arrays will provide more than 1,000 watts of power,

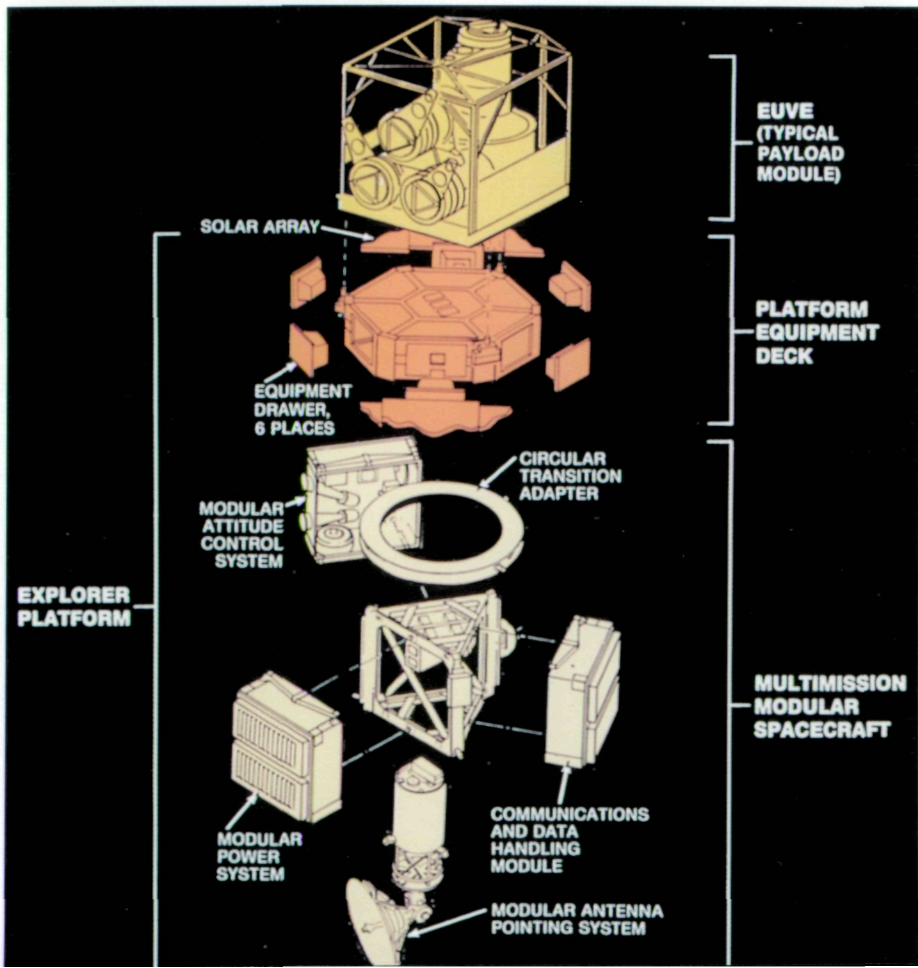




ABOVE: Artist's conception of NASA's Tracking and Data Relay Satellite

LEFT: Support module for the EUVE scientific instruments

BELOW: Cutaway drawing of EUVE spacecraft configuration



averaged over a typical orbit. Of this, a maximum of 300 watts will be allocated to the Payload Module. That allocation is less than one-fourth of the power needed to operate a typical toaster oven, but is ample to run the housekeeping subsystems and scientific instruments on EUVE, all of which use advanced solid-state components. For example, the three EUVE scanner telescopes together use only about 24 watts.

10-Year Lifetime

Solar arrays are known to degrade in low-Earth orbit, where they are struck by high-speed oxygen atoms that induce defects in the cells. Therefore, to insure proper operation of the Explorer Platform over its intended 10-year lifetime, the arrays are designed for easy removal and replacement in space during servicing missions of the Space Shuttle.

Electricity generated by the solar arrays is stored in a Modular Power System (MPS), consisting of the storage batteries, power regulators, and power controllers. Night and day occur about 16 times each per day, as the EUVE operates in low-Earth orbit. Power generated during orbit day is stored in the batteries so that energy is available to operate the spacecraft during orbit night. Ground controllers carefully regulate the constant cycle of battery charging and discharging, so that battery lifetime is maximized consistent with the requirements of on-orbit spacecraft operations. When the batteries fail or deteriorate to an unacceptable extent, as all batteries eventually will, the MPS can be replaced in orbit by a Shuttle astronaut.

Command and Control

EUVE will be operated from a Payload Operations Control Center (POCC) at the Goddard Space Flight Center. Commands will flow to the spacecraft from the POCC, and data obtained by the spacecraft will be routed through to the POCC and then to the Science Operations Center at the Center for EUV Astrophysics at Berkeley.

Tracking Satellite

Normal communications to and from EUVE will be via the Tracking and Data Relay Satellite (TDRS) System. A high-gain antenna, part of the Modular Antenna Pointing System (MAPS), is mounted on a gimbal at the end of an extendable mast (deployed after separation from the launch vehicle) on the EUVE Explorer Platform. (A high-gain antenna is one with a relatively narrow beam, so that it can receive and transmit radio communications in a highly directional manner.) The high-gain antenna on EUVE can be steered by the MAPS to establish communications with a TDRS satellite located high above in geostationary orbit. From the tracking satellite, data are forwarded to a TDRS ground terminal at White Sands, New Mexico, which routes them by land line to the POCC.

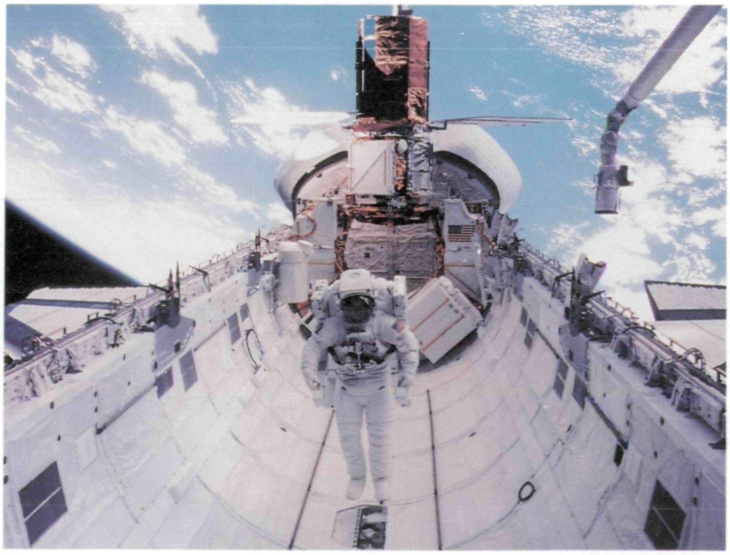
Telemetry is received, processed, and forwarded onboard the Explorer Platform by a replaceable Communications and Data Handling Module. This subsystem stores commands sent from the ground for execution at specified times in both the platform and science instrument systems. It also executes real-time commands from the POCC to operate onboard equipment. It processes the housekeeping telemetry that indicates the state of flight systems and also the science data generated by the EUVE telescopes and the spectrometer. All data are stored in magnetic tape recorders, for playback via the TDRS System to the ground at commanded times.

Backup communications modes are provided via an omnidirectional antenna on the Explorer Platform, which can transmit directly to ground stations located in sight of the spacecraft, and via NASA's Deep Space Network, operated by the Jet Propulsion Laboratory in Pasadena, California.

Newton's Law

The Explorer Platform provides reaction wheels, gyros, and magnetic torquers to stabilize and point the EUVE spacecraft. To steer the spacecraft, the reaction wheels are accelerated by small electric motors, as instructed by commands from the ground. Then, by Newton's Third Law of Motion (every action has an equal and opposite reaction), the spacecraft turns in the opposite direction.

The magnetic torquers, which contain electromagnets that can be energized by ground command, are used to reduce, or "dump" momentum by reacting against the Earth's magnetic field. Otherwise, the reaction wheels would eventually spin too fast. Gyros are used to keep track of exactly where the spacecraft is pointing. The Modular Attitude Control System that incorporates these components receives input data on orientation from star- and Sun-sensors.



Astronaut in shuttle bay with Solar Maximum Mission spacecraft in background

What Will EUVE Find?

As with every Explorer spacecraft, the most remarkable objects that EUVE finds are likely to represent phenomena that scientists have not predicted yet. Nevertheless, from the properties of presently known celestial objects, astronomers predict that among the astronomical bodies that EUVE is likely to detect are red and white dwarf stars, neutron stars, and B-type stars with extended atmospheres heated to high temperatures by shock waves. Other EUVE objects likely to be investigated include binary stars of the RS Canum Venaticorum type, the hot outer atmospheres (coronae) of stars similar to the Sun, and so-called dwarf novae or cataclysmic variable stars.

Additionally, EUVE will investigate physical processes in our solar system—notably in the auroras of Jupiter and possibly of Saturn, and in the Io torus, a doughnut-shaped formation of electrified gas atoms that circles Jupiter at the position of the orbit of its volcanic moon, Io.

Mapping Galactic Gas

Detecting members of each of the classes of stars in our Milky Way galaxy, EUVE will obtain the necessary data to estimate the amount of interstellar gas along the line of sight to the star, and perhaps the relative amounts of the two predominant constituents of the gas, hydrogen and helium, in that direction. This information will allow astronomers to develop basic information on the distribution of interstellar gas in the vicinity of the solar system, and out to distances of hundreds of light-years. In effect, they map not only the distribution of detectable EUV-emitting objects in the sky, but also the distribution of invisible interstellar gas. The map is likely to reveal the existence of some tunnels or lines of sight in which there is very little gas. In these directions, it may even be possible to observe quasars that are located at distances of many millions of light-years.

ABOVE: Total solar eclipse

Not Ordinary

EUV radiation is generated under conditions so different from those that we commonly experience that it necessarily follows that most of the sources that EUVE will detect are remarkable by ordinary standards.

EUV light can arise from intensely incandescent surfaces, like those found in the thick atmospheres of very hot stars, and it can be produced in thinner gases at high temperatures. The radiation can be continuous with wavelength, like the glow from an incandescent light bulb, or it can be characterized by an emission line spectrum, like the light from a neon sign. The glow from a light bulb occurs at wavelengths of visible and infrared light, while many of the likely sources of EUV radiation emit their energy predominantly in that spectral region.

EUV spectral emission lines can be generated also when high-speed electrified, subatomic particles smash into atoms or molecules of familiar gases such as oxygen.

BELOW: White dwarf in planetary nebula

White Dwarfs

Hot, white dwarf stars, with surface temperatures of tens of thousands of kelvins (the Sun's surface temperature is about 6,000 kelvins, or about 11,000 degrees Fahrenheit), are likely to be detected in great numbers by EUVE. Some white dwarfs in our galaxy are even likely to be detected at distances of 3,000 light-years.

EUVE all-sky survey data on these hot, white dwarf stars, combined with data from existing optical and ultraviolet telescopes, will indicate their temperatures and the relative content of hydrogen and helium in their atmospheres. Also, the data will reveal how much interstellar gas is located between each white dwarf star and the Earth. When white dwarfs are examined with the EUVE spectrometer, spectral lines of other elements may be detected, which can be interpreted to yield more information on chemical composition. Theories for the structure of the atmospheric layers in these stars can be tested, and mechanisms by which various elements may diffuse through, or settle in the atmospheres can be elucidated.

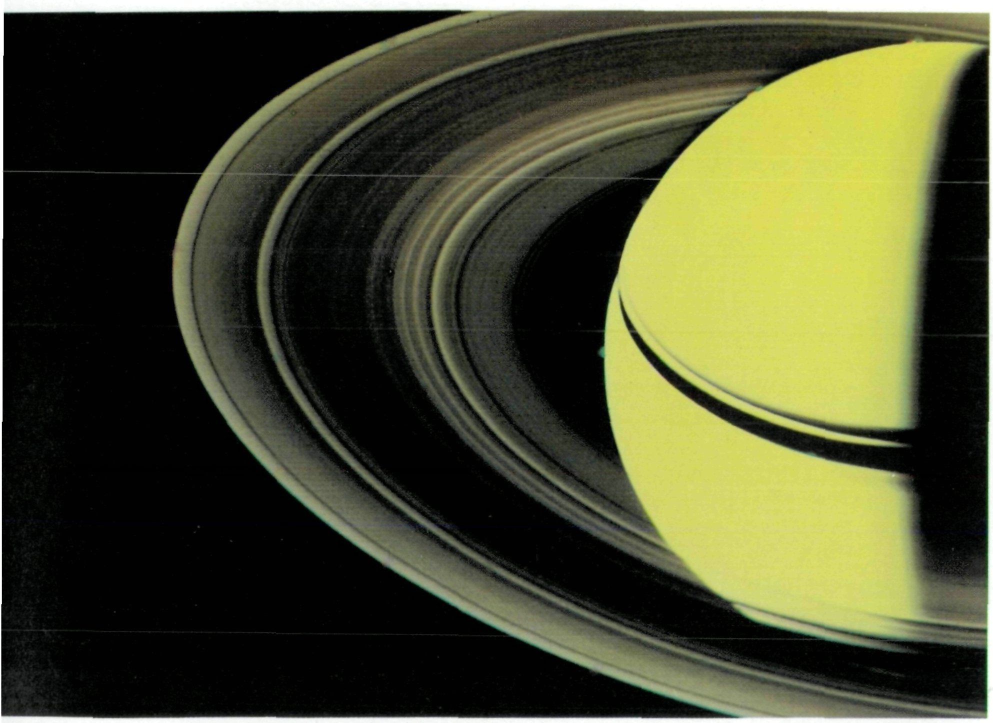
Small and dense, white dwarf stars consist largely of so-called electron degenerate matter, which is not found on Earth. A typical white dwarf has about 65 percent of the mass of the Sun, or about 650 times the mass of the giant planet, Jupiter, yet all of this material is compressed into a tiny star about the same size as the Earth. A single teaspoonful of white dwarf matter would weigh tons on Earth.

White dwarfs are thought to represent the final evolutionary state of stars like our Sun and other stars, ranging upward at the times of their formation to perhaps as much as eight times the solar mass.

During their earlier evolution, these stars must shed much or most of their material in order to eventually become a white dwarf. According to a theory first proposed by the Nobel Prize-winning astrophysicist, Subrahmanyan Chandrasekhar of the University of Chicago, no white dwarf can ever contain more than about 1.44 times the mass of the Sun. In contrast, normal stars made of hot, electrified gases are believed to be capable of forming with masses up to about 120 times the solar mass. So far as is known, a white dwarf star, if isolated from neighbors in space, will slowly cool forever, gradually changing from a source of EUV radiation to just a visible-light source, and eventually dimming into indetectable obscurity. By studying white dwarf stars with EUVE, astronomers will learn about matter existent in strange conditions and about the future, final life stage of our Sun.

Neutron Stars

Neutron stars are even smaller, denser and more massive objects than white dwarfs. A single teaspoonful of neutron star material, if it could be confined, would weigh trillions of tons on Earth. Neutron stars form at higher temperatures than white dwarfs, yet rapidly cool. They are believed to be the remnant cores of supergiant stars that exploded as supernovae, like the great supernova that was seen in the southern sky in February 1987. Some



Voyager-2 photograph of some detail and difference in Saturn's complex system of rings

are known to have powerful magnetic fields and to be rotating at high speed; they are detectable as pulsars, sources of rapidly repeating bursts of radio waves that may be produced as a beam of radio emission turns with the neutron star, like the beam of a rotating radar scanner at an airport. As the neutron star beam rotates past the Earth, astronomers detect a radio burst or "pulse." According to present information, a neutron star that is a typical pulsar gradually spins slower and slower, its magnetic field weakens, and its radio emission cuts off.

There may be millions of dead pulsars (those whose radio emissions have ceased) in our galaxy that are undetectable by present techniques. Yet EUVE may find one or more such dead pulsars, if theoretical speculations pan out. According to these ideas, interstellar gas attracted by the powerful gravity of the dead pulsars may accrete onto their surfaces, reheating them to temperatures of a few hundred thousand degrees. If they get that hot, then although a neutron star is typically no larger than a major metropolitan area (although containing half again as much matter as the Sun and the rest of our whole solar system), it may glow fiercely in extreme ultraviolet light.

It appears that the EUVE offers the best-known possibility of detecting these hypothesized accreting dead pulsars. The detection of even one such object would be a major advance in astronomy. The possibility exists that a dead pulsar lurks within 10 light-years of the Sun, yet has escaped detection by present means. If so, EUVE may find it.

Red Dwarfs

Red dwarf stars, like Proxima Centauri, the nearest known star beyond the Sun, have intense magnetic activity that heats their outer atmospheres or coronae. In these coronae, there often are great explosions called stellar flares, which perhaps mimic the solar flares that occur on our Sun, but which are vastly more powerful.

Similar activity occurs in binary star systems of the RS Canum Venaticorum type (named for the first known system of this type). In this class of binary system, the two member stars are close to each other and are locked in synchronous rotation, so that as they orbit around the center of mass of the system, the same hemisphere of each star always faces toward the other. In contrast, as the Sun turns once every 27 days, we on Earth see first one hemisphere and then the other.

Studies with x-ray telescopes and the International Ultraviolet Explorer (IUE)

reveal that disturbed regions in the atmospheres of these binary stars are the sites of intense magnetic activity, like giant analogs of the sunspots on our own star. Flares also occur in the atmospheres above these regions.

EUVE is expected to glean important, new information about the coronae and flares of red dwarf stars and RS Canum Venaticorum systems. EUVE also should detect interesting EUV spectra from the hot, outer layers of other classes of nearby cool stars.

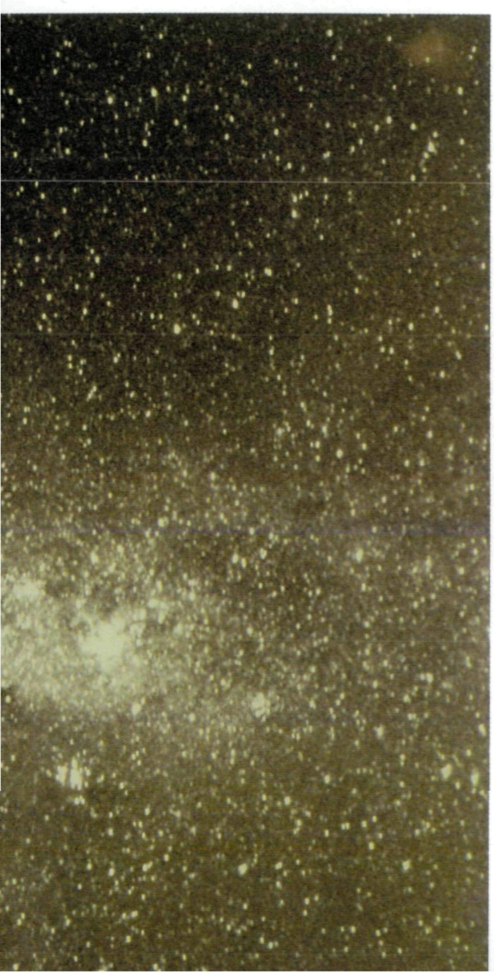
Observations by the Einstein and EXOSAT satellites showed that many types of cool stars, including "main sequence" stars like the Sun, familiar bright stars such as Capella and Procyon, and red dwarf stars, emit soft x-rays. The radiation presumably comes from the upper atmospheres of these stars, which are much hotter than their surface layers.

Soft x-rays are those with relatively low energies and relatively long wavelengths; they constitute the region of the electromagnetic spectrum that adjoins the EUV on its short-wavelength-side.

The Einstein and EXOSAT findings have led astrophysicists to infer that many of these cool stars also must be strong EUV emitters, even if they do not undergo major flares or other eruptions. Calculations suggest several thousand cool stars should be detected and studied in the EUVE all sky-survey.

LEFT: Crab Nebula containing a neutron star at its center

BELOW: Proxima Centauri, a Red Dwarf star appearing as a very tiny point of light adjacent to Alpha Centauri (lower left quadrant)



B Stars

Early type-B stars like the familar Spica, brightest star in the constellation Virgo, have unexpectedly proved to possess extended coronae. In these huge, outer atmospheres of the B stars, the gases probably are heated by shock waves generated when a faster-moving wind from the star crashes into slower-moving gas that left the lower layers of the star at an earlier time. Or, fast and slow gas currents may collide in some as-yet-unspecified way. In any case, just as a shock wave or sonic boom precedes the supersonic transport, Concorde, as it flies through the nearly stationary gases of the Earth's lower atmosphere, shock waves occur in a B-star corona when the fast moving streams move through coronal regions at speeds greater than the local speed of sound. Much energy is released, making the corona so hot that it glows brightly in the EUV. Observations by the EUVE spectrometer are expected to detect spectral lines in the 80- to 120-Angstrom spectral range that can be analyzed to determine temperatures, densities, and other physical conditions in these unusual stellar atmospheres. The data should allow EUVE observers to test and perhaps distinguish between the different theories of these shock-heated winds that were recently proposed by Joseph Cassinelli of the University of Wisconsin and Rolf-Peter Kudritzki of the Max Planck Institute of Astronomy and Astrophysics in Munich, Federal Republic of Germany.

Dwarf Novae

Dwarf novae are a fascinating subject for study by the EUVE. These so-called cataclysmic variable stars are actually binary star systems in which an ordinary main sequence star, not remarkably different from our Sun, is closely orbiting a common center of gravity with a white dwarf star companion.

Because of the powerful gravity of the white dwarf, gas streams out from the atmosphere of the main sequence star and falls down on the white dwarf, spiralling inward toward it through a structure known as an accretion disk. As the gas in the disk spirals closer and closer toward the white dwarf star, it moves into a smaller and smaller

Early-type B stars in Pleiades

volume. Therefore, the density of the falling gas inexorably increases. In effect, the gas is being compressed by the gravity of the white dwarf star. Because a compressed gas becomes hotter (and when it expands it cools, the principle on which home refrigerators and air conditioners work), the gas in the accretion disk of the dwarf nova system get hotter and hotter, and accordingly it glows in the EUV.

At irregular intervals of days, weeks, or months, eruptions occur in the accretion disk. During these eruptions, one of which was actually observed by the EUV telescope during the Apollo-Soyuz Test Project in 1975, there occur great outbursts of extreme ultraviolet radiation. Studies of dwarf novae with the EUV will yield basic physical information about these strange star systems and how they explode.

Io Torus

EUVE also will yield basic new information about the planet Jupiter and its strange planet-girdling gaseous belt, the "Io torus," which glows in invisible forms of radiation, including the extreme ultraviolet.

Io is one of the four large moons of Jupiter discovered by Galileo in the early 17th century. The great Italian astronomer could hardly have imagined that almost four centuries later, the Voyager-1 spaceprobe would pass near the moons that he first glimpsed and would discover frequently- or constantly-erupting volcanoes on Io, which release huge amounts of sulfur and oxygen in various forms into trans-Jovian space. Some of these substances become individual ions (electrified atoms) that orbit Jupiter at roughly Io's distance from the planet, spreading out to fill a doughnut-shaped plasma cloud, the Io torus.

Other charged particles stream down the lines of magnetic force that loop far out from Jupiter and pass through the region of Io. Striking the upper atmosphere of the giant planet near the polar regions, the charged particles stimulate atoms and molecules, making them glow in an ultraviolet aurora that is reminiscent of the aurora borealis and australis (the northern and southern lights) sometimes seen on Earth.

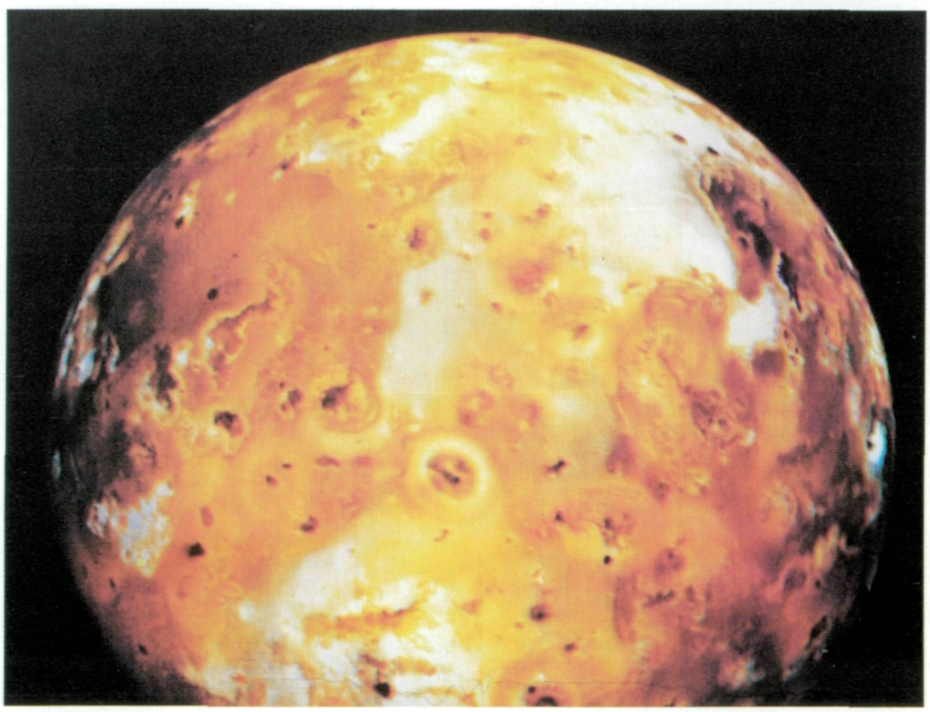
The EUVE spectrometer will gather basic new data on the spectral properties of the Io torus and the Jovian aurorae and may be capable also of gathering such data on aurorae on the planet Saturn or even on distant Uranus. From this information, aeronomers—scientists who specialize in the physical study of light emissions and physical processes in planetary atmospheres—will learn about the particles that stimulate the observed glows, the atoms and molecules involved in the glows themselves, and the natural processes at work.

Quasars

Quasars are as a class, the most distant and powerful sources of energy in the known universe. Some quasars blaze forth so brightly that present telescopes can glimpse them at distances far beyond almost all identified galaxies.

Yet a quasar is apparently an object no larger than our solar system, and a typical galaxy contains hundreds of billions of stars like the Sun.

The mystery of why a tiny quasar can outshine a huge galaxy remains unsolved, despite almost 30 years of study by hundreds of astronomers since the first quasars were found. The leading idea postulates that at the heart of the quasar there is a supermassive black hole, a region of space in which matter amounting to hundreds of millions of solar masses is packed into a radius so small that the gravitational force exerted is too powerful to allow the escape of a ray of light.



TOP: Center of Andromeda Galaxy, one of the nearest to our own Milky Way

ABOVE: Io, Jupiter's volcanic Moon, from Voyager-1

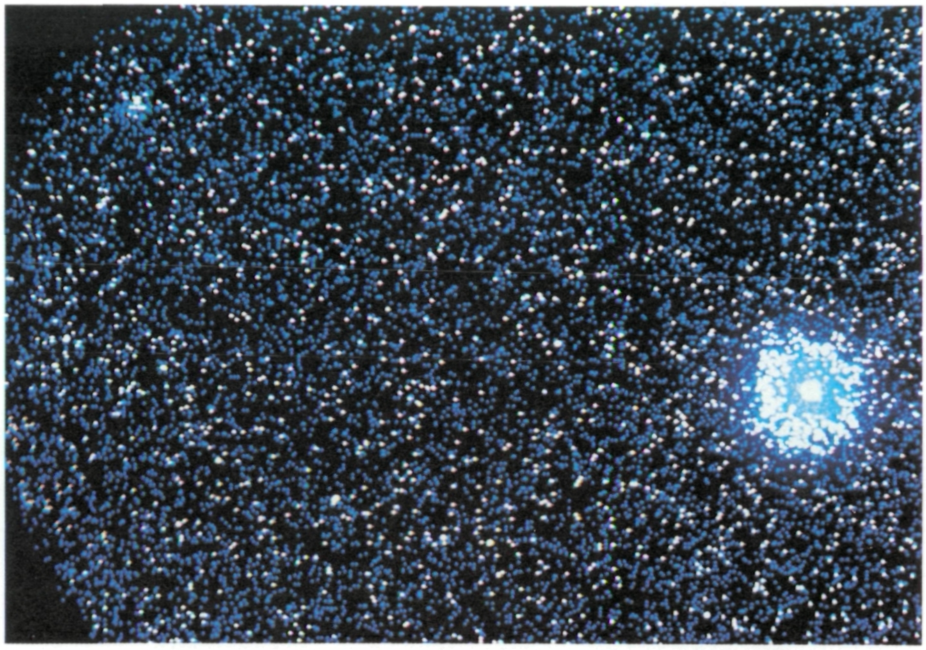
Around the supermassive black hole, some experts postulate that there is a "reprocessing region," where electromagnetic radiation is reduced in energy (increased in wavelength) as it passes through a hot gas. Whether or not this is true, many investigators consider that the putative black hole is surrounded by an accretion disk. This structure must be much larger than the accretion disk in the dwarf nova system, but presumably it forms in the same way, through the infall or matter toward the black hole.

Recent findings suggest that the EUVE can help to explore the nature of either or both of these two hypothetical structures, the reprocessing region and the accretion disk.

Specifically, x-ray observations made from space show that many quasars have an unexpected emission in the longest wavelength x-rays, which border on the EUV region of the spectrum. Extrapolation suggests that this same emission might be very strong in the EUV and theorists propose that the radiation may be coming from the quasar accretion disk and perhaps from the reprocessing region, if one exists.

At the same time, if a number of relatively gas-free lines of sight exist, it might be possible to view extragalactic space through them and perhaps detect the EUV radiation from a quasar in that direction. This may be a long shot, but the scientific results, should this difficult quasar observation succeed, could include fundamental new information on one of the greatest puzzles in modern astronomy—the nature and energy source of quasars.

Quasar 3C273, a very distant object with extremely high energy, observed for the first time in x-ray by HEAO-2 spacecraft



EUVE Mission Management

The EUVE Program is a component of the Astrophysics Program conducted by the Office of Space Science and Applications at NASA Headquarters in Washington, D.C. Direct management responsibility for developing and operating EUVE, including the Explorer Platform and Payload Module, is vested in the Goddard Space Flight Center, Greenbelt, Maryland.

The Center has contracted with the University of California at Berkeley for the design, fabrication, integration, calibration and test of the scientific instruments, the conduct of the all-sky survey, and the development of the necessary computer software for the processing and scientific analysis of data from the EUVE telescopes and spectrometer.

A Flight Operations Team will staff the EUVE Payload Operations Control Center (POCC) at Goddard to control mission operations and conduct short-term and long-range mission planning.

To perform their assigned development tasks, the Berkeley astronomers have built a state-of-the-art, low-contamination EUV instrument calibration facility. It incorporates a vacuum chamber with a capacity of 3×5 meters (about 10×16 feet) which is entered after passing through a series of clean rooms, to control contamination by airborne dust and other substances that can degrade sensitive optical and sensor components.

To coordinate science operations planning and the control, performance monitoring, and data collection from the scientific instruments, the Berkeley scientists have established an EUVE Science Center at the University. This includes a Science Operations Center (SOC), a Science Data Storage Facility, and a Science Data Analysis Facility, all equipped with appropriately-networked computer workstations. The EUVE Science Center will manage the Guest Observer Program during the Spectroscopy Phase of the EUVE Mission, when Guest Observers selected by NASA Headquarters will study data obtained with the EUVE.

The SOC will work closely with the mission planners at Goddard to coordinate the acquisition of scientific measurements by EUVE and the proper commanding of the scientific instruments on board. The SOC will support both the all-sky survey planning and the development of spectroscopy observation plans for Guest Observers. The Science Data Analysis Facility will provide an archive for the raw science telemetry from EUVE and for the processed data. Members of the Berkeley science team will use the facility to produce the all-sky survey catalog and sky map, and to study data from the EUVE deep survey. Guest Observers will study these data and the spectroscopy observations from EUVE, using computer tools at the facility, or by analyzing magnetic tapes or electronically transmitted data files at their home institutions.

Instrument Calibration Facility at University of California at Berkeley

EUVE Team

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EUVE Payload Module Manager	Mr. Richard M. Day
EUVE Mission Operations Manager	Mr. Hector Zayas

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